The Potential for Wood-based Biofuels – Economics and Policy Considerations

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Topics

- National background – An Energy crisis?
- Ambitious Goals! to make ethanol and biodiesel
- Estimated huge amounts of cellulosic feedstocks are available
- Several types of technologies could make biofuels from cellulose
- Near term? – add biofuels production to pulp mills
- Longer term? – stand alone cellulosic biorefineries
- When will biofuels from wood be economical ?
- Issues for forest management, land owners, loggers in supplying wood

USDA Forest Service

Forest Products Lab, Madison, WI

My perspective

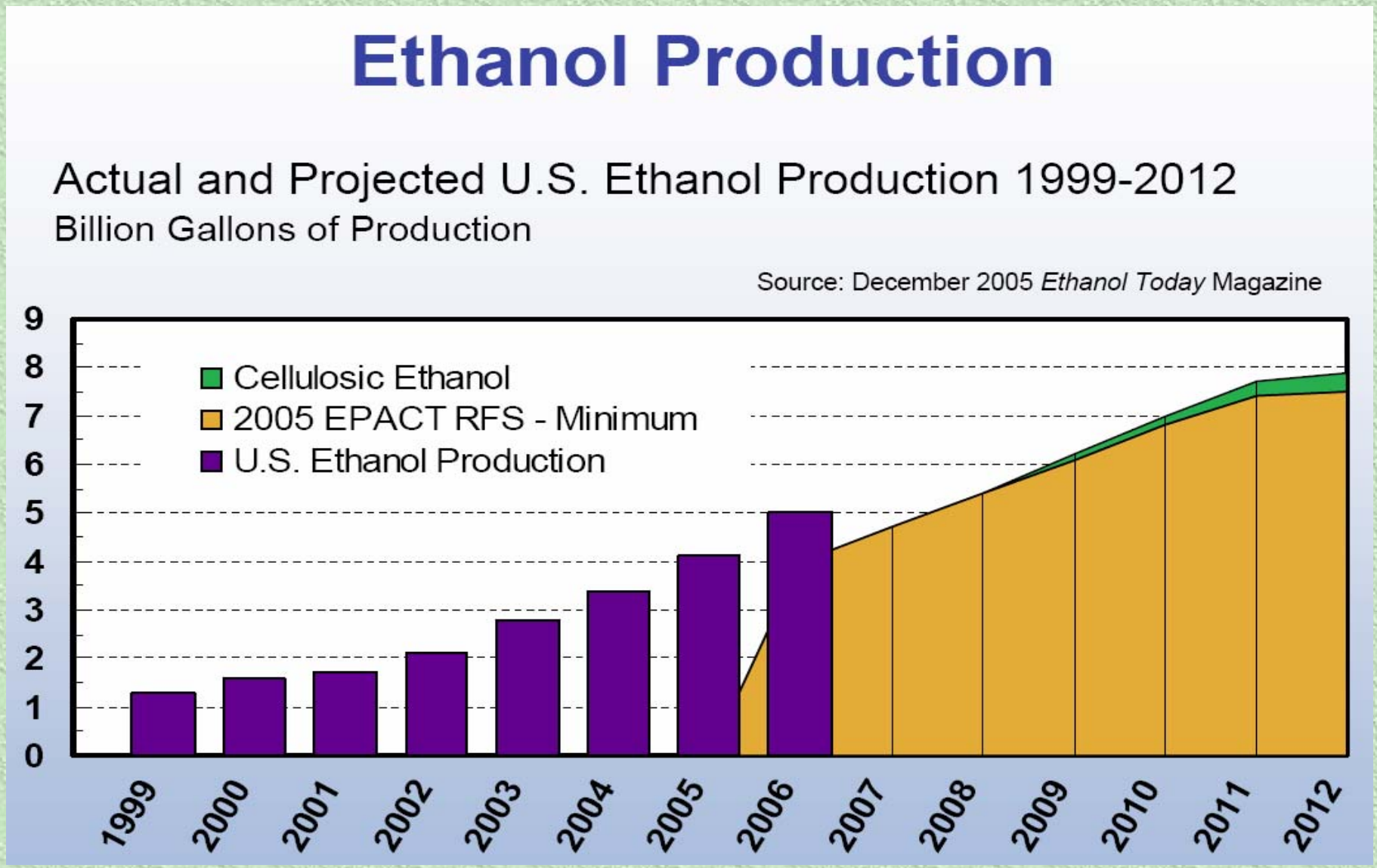
- **FPL focus on developing wood biorefinery technology**
- **What wood biorefinery businesses will be economically feasible?**
- **What wood resources will be used ?**
- **Impact of increased wood use on wood markets**

National background – An Energy crisis?

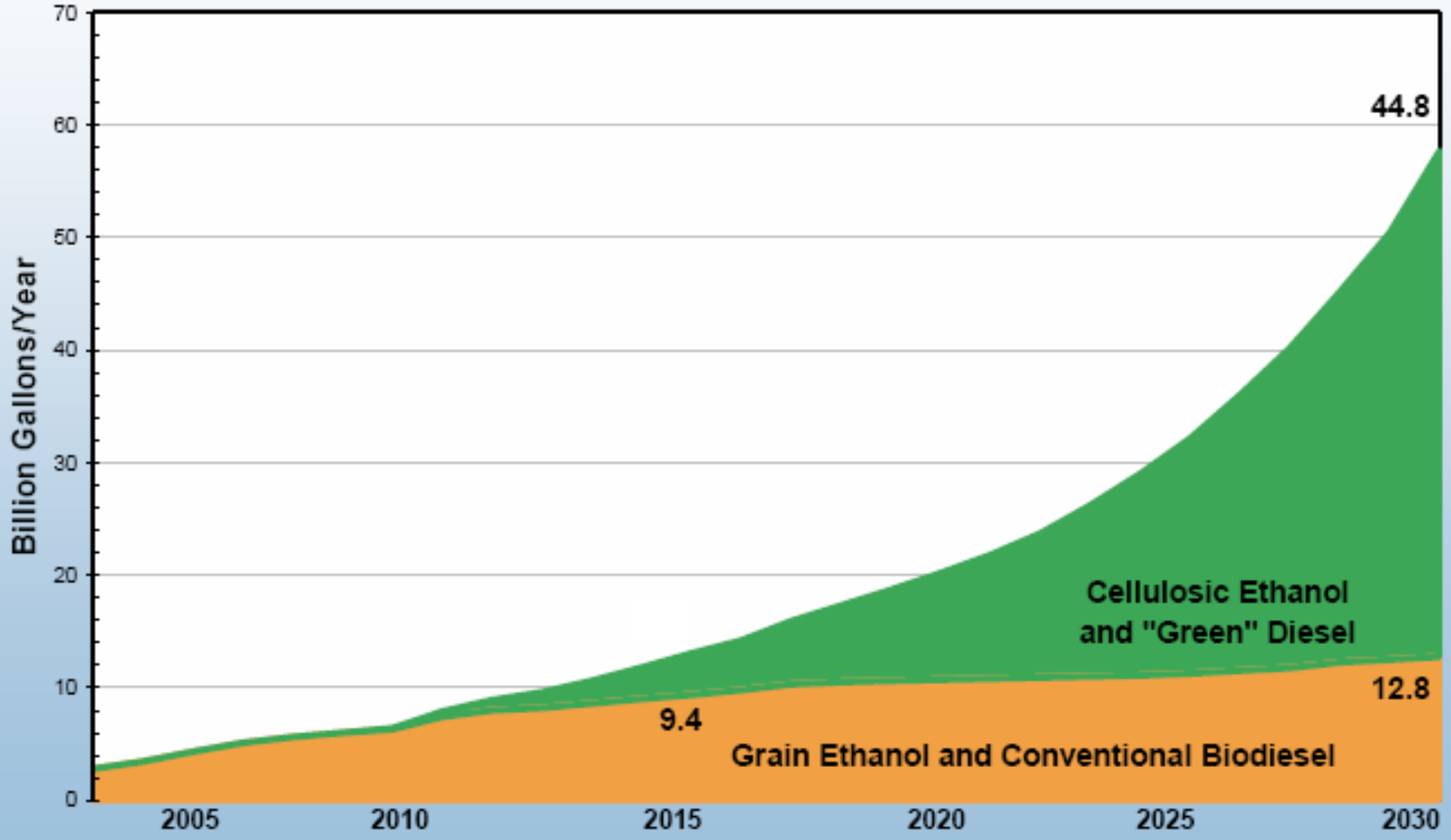
Ambitious! goals

- In 2006 the U.S. imported 66% of the petroleum it consumed, up from 35% in 1975
- “The U.S. is addicted to oil.”, The President, 2006 State of the Union Address
- The President’s Biofuels goals–
  - Replace 30% of our current (2004) gasoline use with biofuels by 2030 (60 bil gals ethanol)
  - Reduce gasoline use by 20% in 10 years (2017)
  - Make cellulosic ethanol cost-competitive with gasoline by 2012
  - Produce 250 million gallons of cellulosic ethanol by 2013

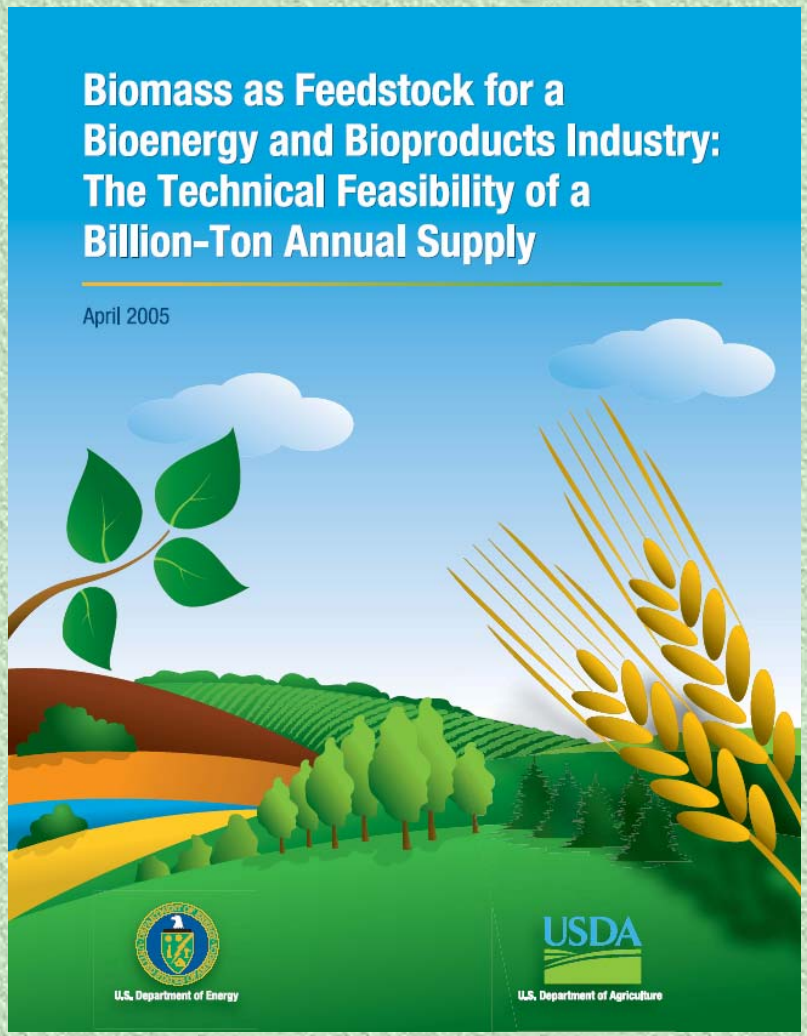
Ethanol goals for 2012



Required Growth of Cellulosic Ethanol to Supply 30% of U.S. Gasoline Demand by 2030



Estimated huge amounts of cellulosic feedstocks are available



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A Joint Study Sponsored by
U.S. Department of Energy
U.S. Department of Agriculture

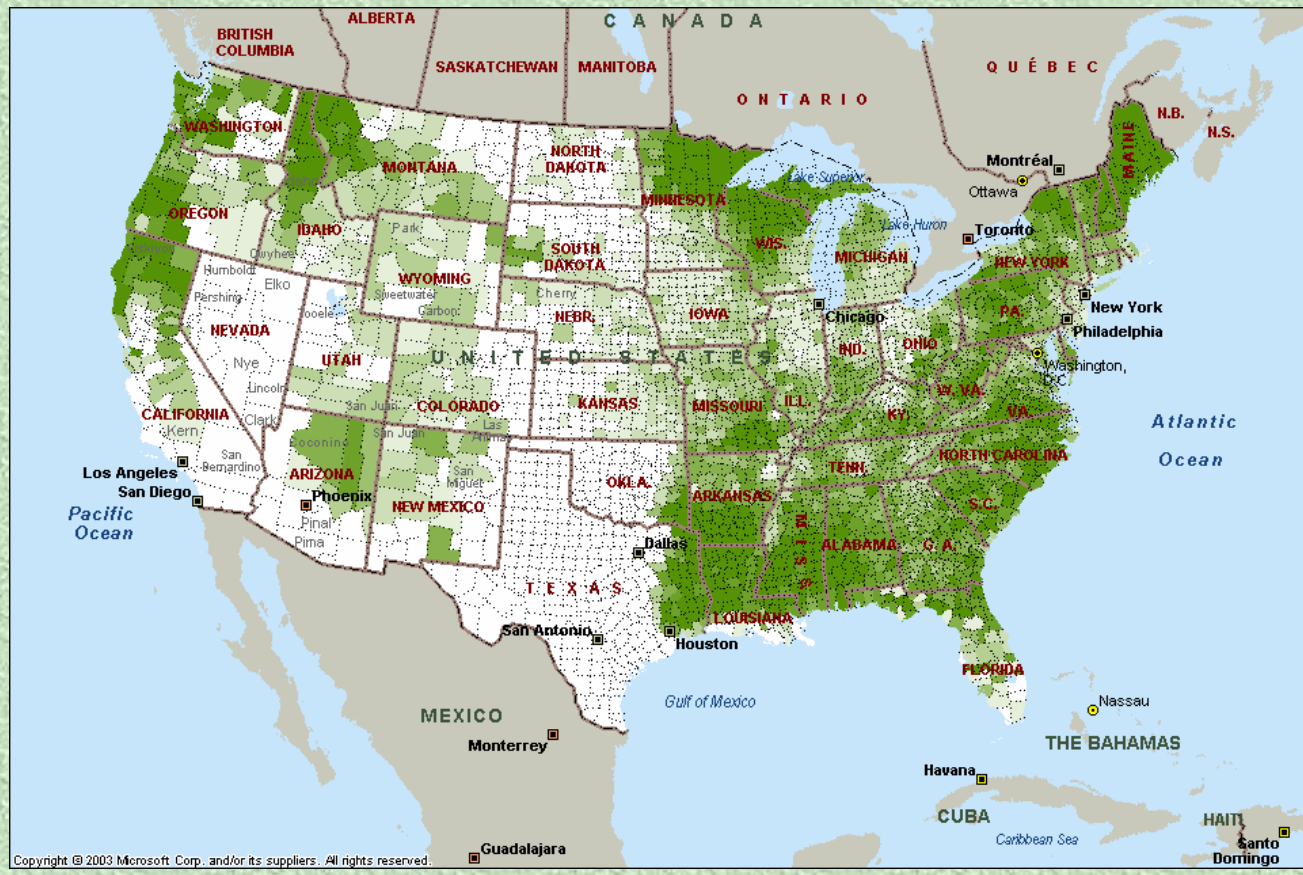
http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

Cellulosic feedstock sources

- **Forest and Ag land = one-half of the contiguous U.S.**
  - Forestland resources: 504 million acres of timberland, 91 million acres of other forestland
  - Agricultural resources: 342 million acres cropland, 39 million acres idle cropland, 68 million acres cropland pasture
- **Forest resources**
  - **Logging residues**
  - **Forest thinnings**
  - Fuelwood
  - **Primary wood processing mill residues**
  - Secondary wood processing mill residues
  - Pulping liquors
  - Urban wood residues
- **Agricultural resources**
  - Crop residues (e.g. corn stover)
  - Perennial grasses (e.g. switch grass)
  - **Perennial (short rotation) woody crops**

Example of an additional wood resource – Logging residue, land clearing

- 70 million dry tons generated annually
- Collect 50% to 65% (public vs private lands)
- **~ 41 million dry tons/year**
- **Estimated to increase to ~ 64 million dry tons/year**



1.3 billion dry tons potentially available

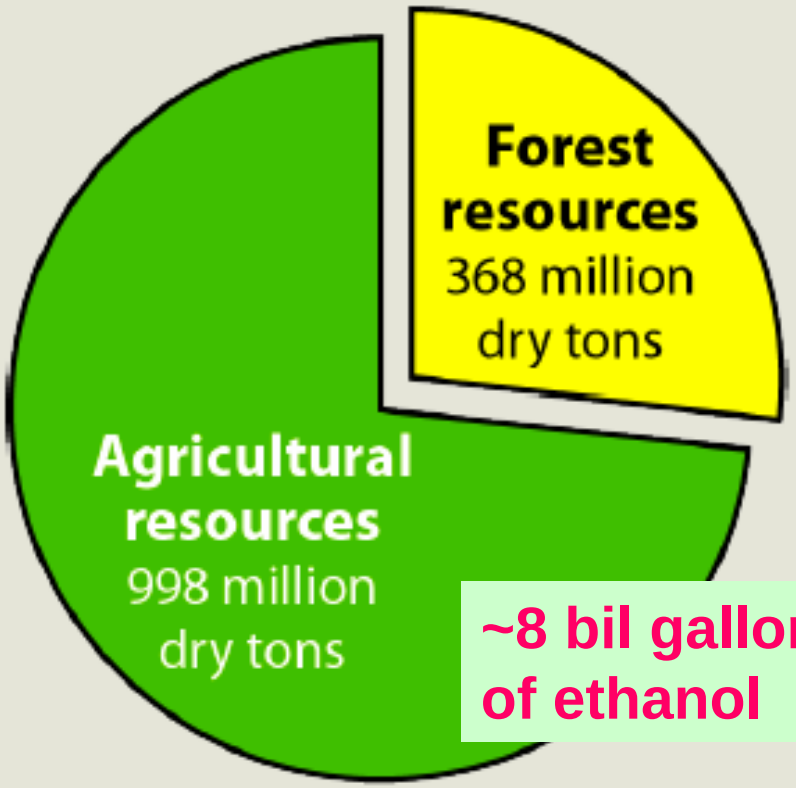


Fig. A. Potential Biomass Resources: A Total of More than 1.3 Billion Dry Tons a Year from Agricultural and Forest Resources.

~8 bil gallons of ethanol

Table A. Potential Biomass Resources

Biomass Resources	Million Dry Tons per Year
Forest Biomass	
Forest products industry residues	145
Logging and site-clearing residues	64
Forest thinning	60
Fuelwood	52
Urban wood residues	47
Subtotal for Forest Resources	368
Agricultural Biomass	
Annual crop residues	428
Perennial crops	377
Miscellaneous process residues, manure	106
Grains	87
Subtotal for Agricultural Resources	998
Total Biomass Resource Potential	1366

2005 US wood harvest = 260 bil dry tons

Technologies to make ethanol/ bio oil from wood

- **Thermochemical conversion**
- Input: **chips with bark** (mill residue, tops/ branches/ whole tree chips, short rotation hardwood crops or pulping liquor)
  - Processes/ outputs
    - 1- **Gasification**
      - gasification to syngas – mix of CO, CO_2, H
      - Convert syngas to ethanol or other biofuels & chemicals
    - 2 -**Pyrolysis**
      - Bio oil – refine bio oil into transport fuels and chemicals
- **Biochemical conversion**
- Input: **clean chips** – hardwoods preferred (pulpwood, short rotation hardwood crops)
  - Processes/ outputs
    - Extraction of sugars from wood (+ chemical byproducts)
    - Fermentation of sugars to ethanol
    - 3 - **Extract and process hemicellulose** from wood prior to pulping
    - 4 – **Extract and process sugars from clean chips**

Possible wood Biorefinery Processes

Feedstock production, collection, handling & preparation

Hydrolysis
Acids, enzymes
→ **Sugars & Lignin**

Gasification
High heat, low oxygen
→ **Synthesis Gas**

Digestion
Bacteria
→ **Bio-gas**

Pyrolysis
Catalysis, heat, pressure
→ **Bio-Oil**

Extraction
Mechanical, chemical
→ **Carbon-Rich Chains**

Separation
Mechanical, chemical
→ **Plant Products**

USES

Fuels:
- Ethanol
- Renewable Diesel
- Hydrogen

Power:
- Electricity
- Heat

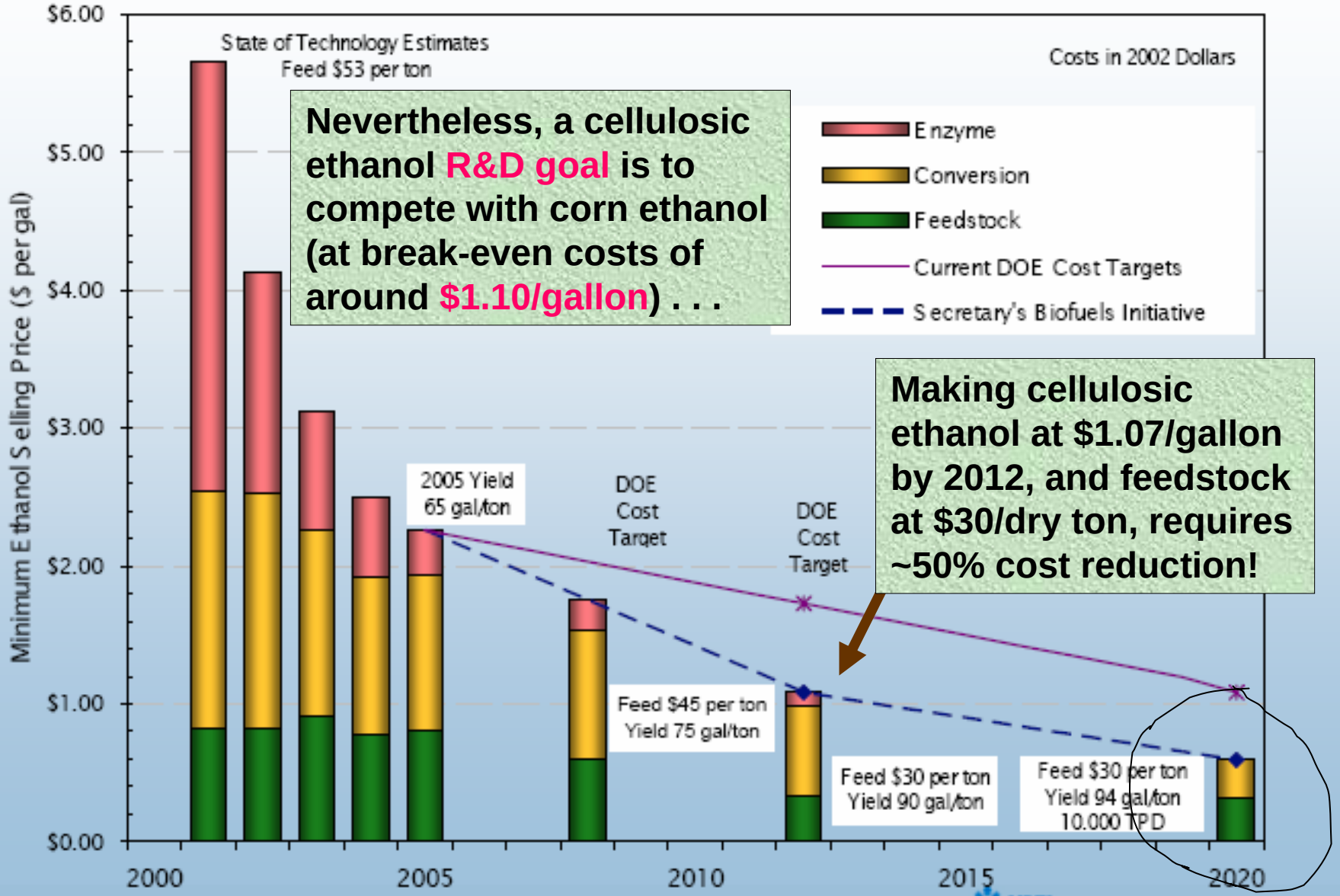
Chemicals:
- Plastics
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Furfural
- Fatty acids
- Acetic Acid
- Carbon black
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Etc.

Food and Feed

Additions to pulp mills or Stand alone

- **Thermo chemical (gasification or pyrolysis)**
  - **Advantages**
    - Could add to existing pulp mills
    - Can use wood, bark, ag residues
    - Can start at limited size and scale up at pulp mills
    - Additional wood can be from forest residues – may not compete for pulpwood supply
  - **Challenges/ needs**
    - Production limited at pulp mill sites
    - Need steady, sustainable supply of wood residue or ag residue
    - Need harvest /haul systems wood at low cost (DOE goal ~$30 / dry ton)
    - **Example - Soperton Georgia project**
    - **Example – Phases 2 & 3 - Flambeau River Paper, Park Falls, WI**

Biofuels Cost Targets



Source: Dr. Stanley Bull, NREL, "Non-Carbon-Emitting Technologies for the Future", May 8, 2006

Additions to pulp mills or Stand alone

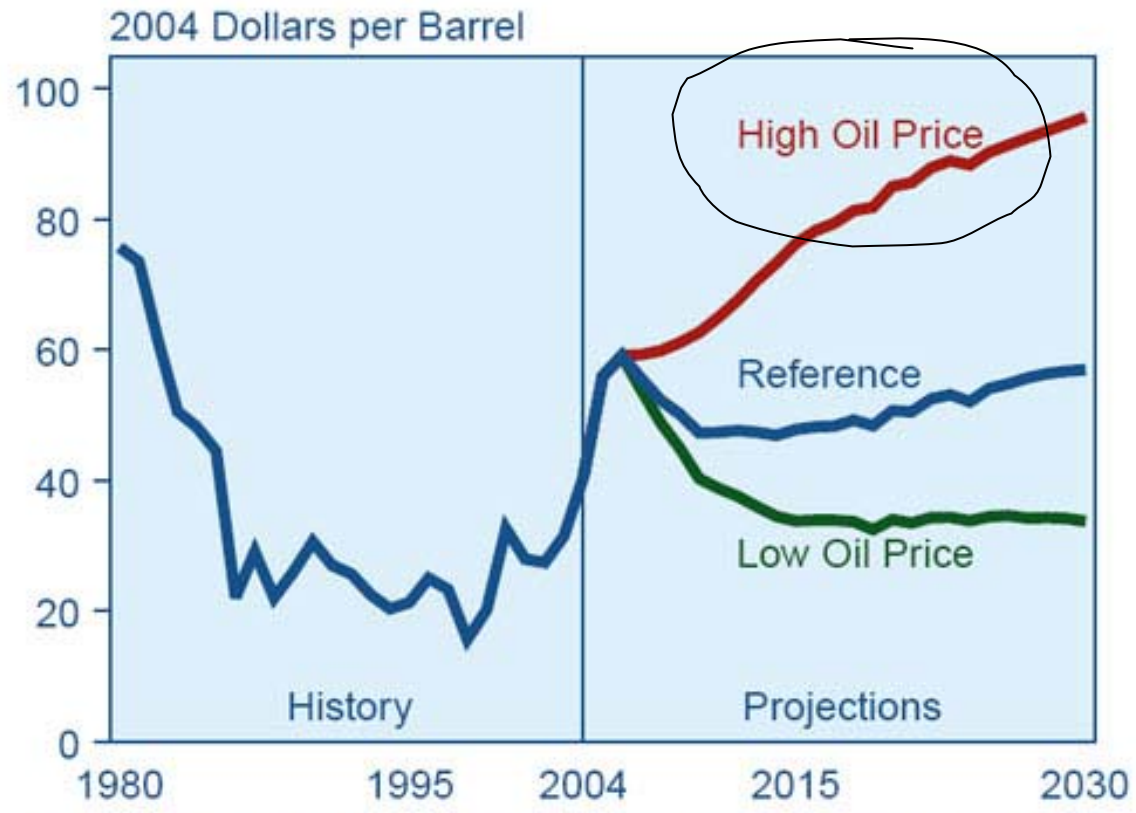
- **Bio chemical at pulp mills**
  - Advantages
    - Uses already delivered wood - extract and process hemicellulose (called value prior to pulping)
    - No additional feedstock costs
  - Challenges/ needs/ limitations
    - Limited by the amount of pulp processed (up to ~ 2 bil gal)
    - May reduce paper strength
    - **Example – Phase 1- Flambeau River Paper, Park Falls, WI**
- **Bio chemical stand alone biorefinery**
  - Advantages
    - Could use mix of wood and ag materials
  - Challenges/ needs/ limitations
    - Needs clean chips that would compete with pulpwood supply
  - Need to get wood costs down to compete with corn/ corn stover
    - Need better conversion to ethanol - 80 vs 63 gal/ dry ton)
    - Need low feedstock cost ~ $30 / dry ton

When will biofuels from wood and ag residues be economical ?

- Estimated current ethanol production costs
  - Corn ~ $1.10 / gal
  - Cellulosic plants - up to $2.25/gal ?
- What do we need for cellulosic to be competitive with corn?
  - Low cost wood/ ag residue feedstock
    - ~ $30/ dry ton (currently ~ $60/ dry ton for pulpwood)
  - Increased ethanol recovery
    - From ~65 gal/ dry ton to ~90+ gal/ dry ton

DOE Projections of World Oil Prices to 2030

Figure 32. World Oil Prices in Three Cases, 1980-2030

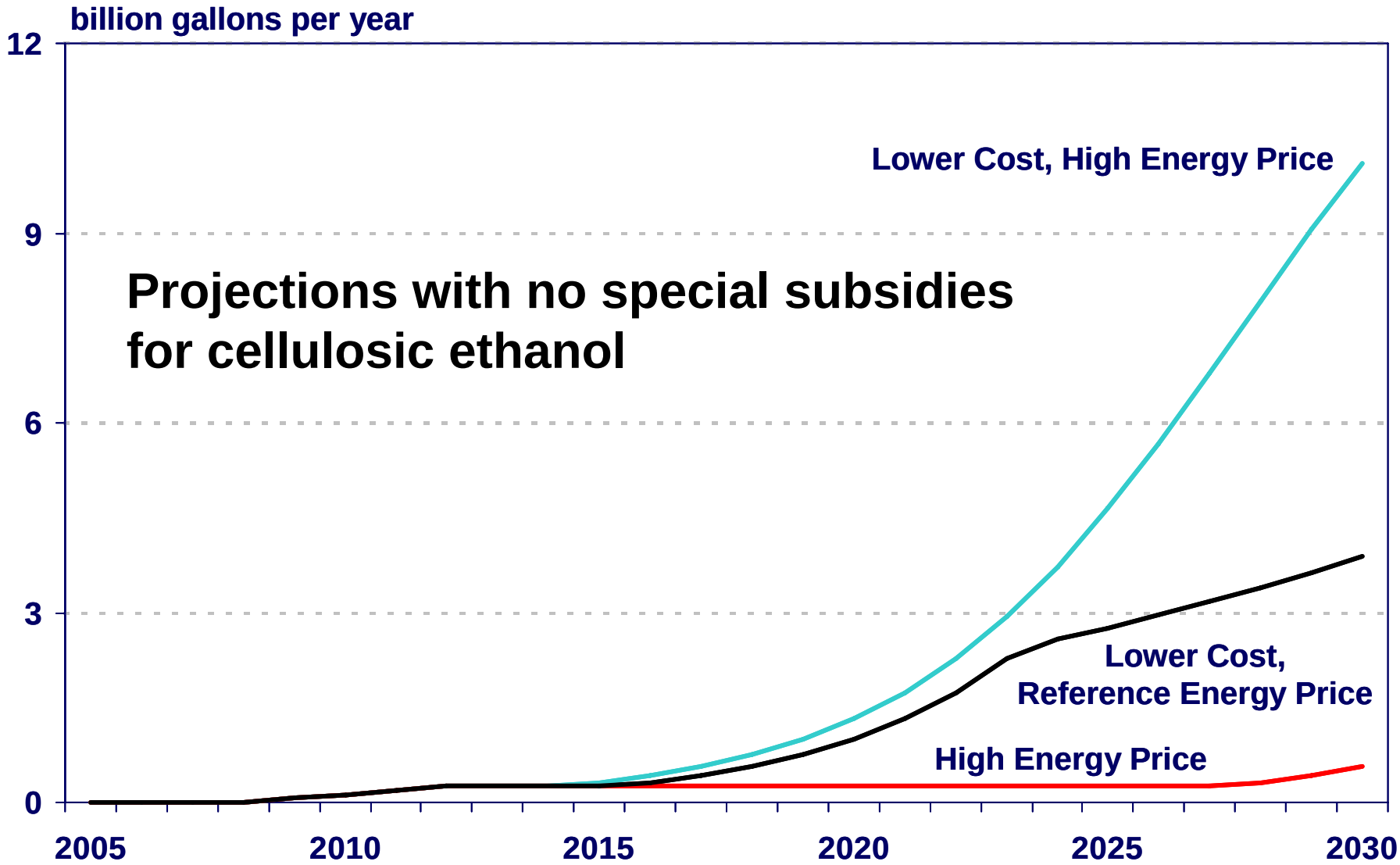


Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2004*, DOE/EIA-0384(2004) (Washington, DC, August 2005), web site www.eia.doe.gov/emeu/ aer/. **Projections:** EIA, *Annual Energy Outlook 2006*, DOE/EIA-0383(2006) (Washington, DC, February 2006).

Current oil price =

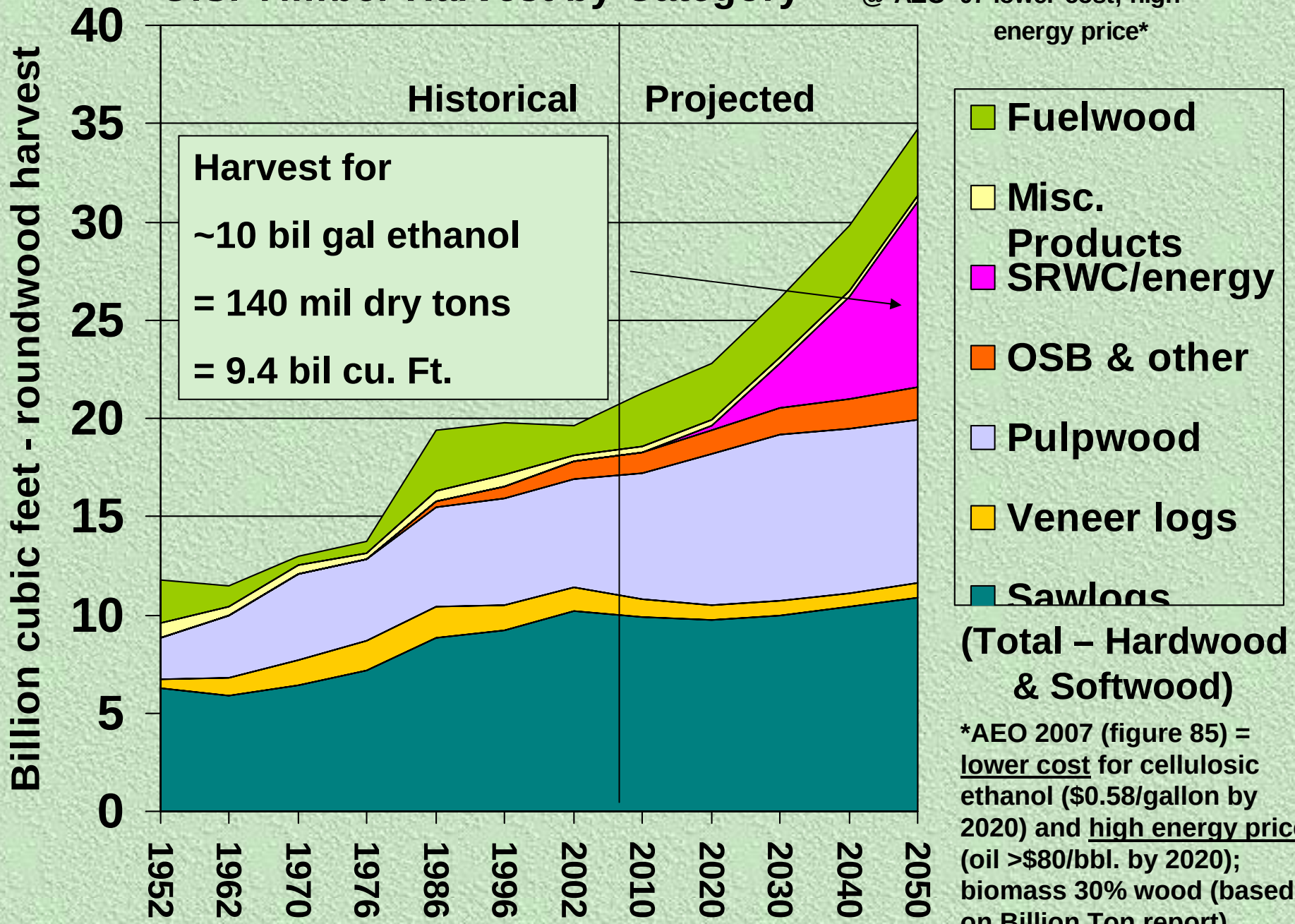
~$60/ barrel

U.S. Cellulose Ethanol Production, 2005-2030



Annual Energy Outlook 2007, Figure 85

U.S. Timber Harvest by Category - @ AEO '07 lower cost, high energy price*



(Total – Hardwood & Softwood)

*AEO 2007 (figure 85) = lower cost for cellulosic ethanol ($0.58/gallon by 2020) and high energy price (oil >$80/bbl. by 2020); biomass 30% wood (based on Billion Ton report)

When will biofuels from wood and ag residues be economical ?

Government actions that will support cellulosic/ wood ethanol even without $70 oil price

- That support cellulosic ethanol generally
  - Raise the Renewable Fuels Standard (ethanol target) above 7.5 bil gals for 2012 (e.g. require 10% ethanol blend in all gasoline or higher)
  - DOE funding for cellulosic plants (6 just funded)
  - Reverse auction for subsidy needed by plants to make cellulosic ethanol (in addition to current 51 cents/ gal) to get to 250 million gallon goal for 2013 (to begin Aug 08)
- That support wood ethanol specifically
  - DOE/ State funding for wood ethanol plant
  - Wood ethanol plant wins subsidy in reverse auction

Proposed gasification plant
Range Fuels, Soperton, GA

- **Awarded DOE Funding – up to $76 million Feb 28, 2007**
- Thermo-chemical conversion
  - Gasification to syngas with catalytic conversion to ethanol and methanol
- Feedstock - 1,200 tons per day of wood residues and wood based energy crops.
- 40 million gallons of ethanol and 9 million gallons of methanol per year.
- Construction to begin 2007

Proposed biochemical /thermochemical plant Flambeau River Paper, Park Falls, WI

- Phase 1
  - Produce Ethanol by extraction and fermentation of hemicellulose from existing pulpwood input
  - 40 million gallons of ethanol per year.
- Phases 2 and 3
  - Thermochemical conversion of additional 200,000 to 400,000 dry tons/ year wood residue to syngas and/ or ethanol/ chemicals

Issues for forest management, land owners, loggers in supplying wood feedstock

- Issues If thermochemical wood ethanol plants expand (using logging residue/ tops, limbs, branches / thinning material)
  - How to provide low cost forest residue – What are forest residue supply practices - forest management / logging practices
    - How much can be taken?
    - What harvest systems would be used?
    - What would delivered costs be?
- Role of state programs?
- Role of demonstration projects?
- "Issues" if biochemical wood ethanol plants expand (using clean wood chips)
  - No new issues if only existing pulpwood (hemicellulose) is used
  - If more clean chips are used, demand and price for "pulpwood" will be higher

Conclusions

- Commercialization of cellulosic biofuels production is in its infancy
- Economic outlook is uncertain
  - Future oil price
  - Future technology improvement
  - There are major government grants/ loan guarantees /R&D efforts / possible reverse auction subsidy
- First commercial wood ethanol plants seems likely to be thermochemical (gasification)
- Thermochemical plants could expand use for forest residue (logging residue/ tops, branches, thinnings) and shift use of mill residue
- Biochemical conversion of hemicellulose at pulp mills could provide ethanol with little increase in wood consumption
- Biochemical conversion at stand alone mills may compete for and raise prices for pulpwood

Questions

Discussion

Web sites

Ethanol history/ timeline -
www.eia.doe.gov/kids/history/timelines/ethanol.html

Presidents biofuels initiative –
www1.eere.energy.gov/biomass/initiative_sheet.pdf

DOE Biomass Energy Program - www1.eere.energy.gov/biomass/

Proposed wood ethanol plant in Soperton, GA -
www.rangefuels.com/range_fuels_to_build_first_wood_cellulosic_ethanol_plant_in_georgia

Proposed Flambeau River Paper Co. biorefinery, Park Falls, WI -
www.americanprocess.com/CellulosisEthanolTakesOff.html

Contact: Ken Skog – kskog at fs.fed.us

Wisconsin initiatives

- **Goal –** 25% of state's electricity and 25% of transportation fuel from renewable fuels by 2025
- **Wisconsin Energy Independence Fund -** $50 million in loan guarantees and low interest loans to expand production and use of renewable fuels and energy (Sept 25, 06)
- **Wisconsin Energy Independence Grant Program ($20 million) -** One grant worth $5 million for the first cellulosic ethanol manufacturer to Wisconsin (Sept 25, 06)

Biofuels production pathways